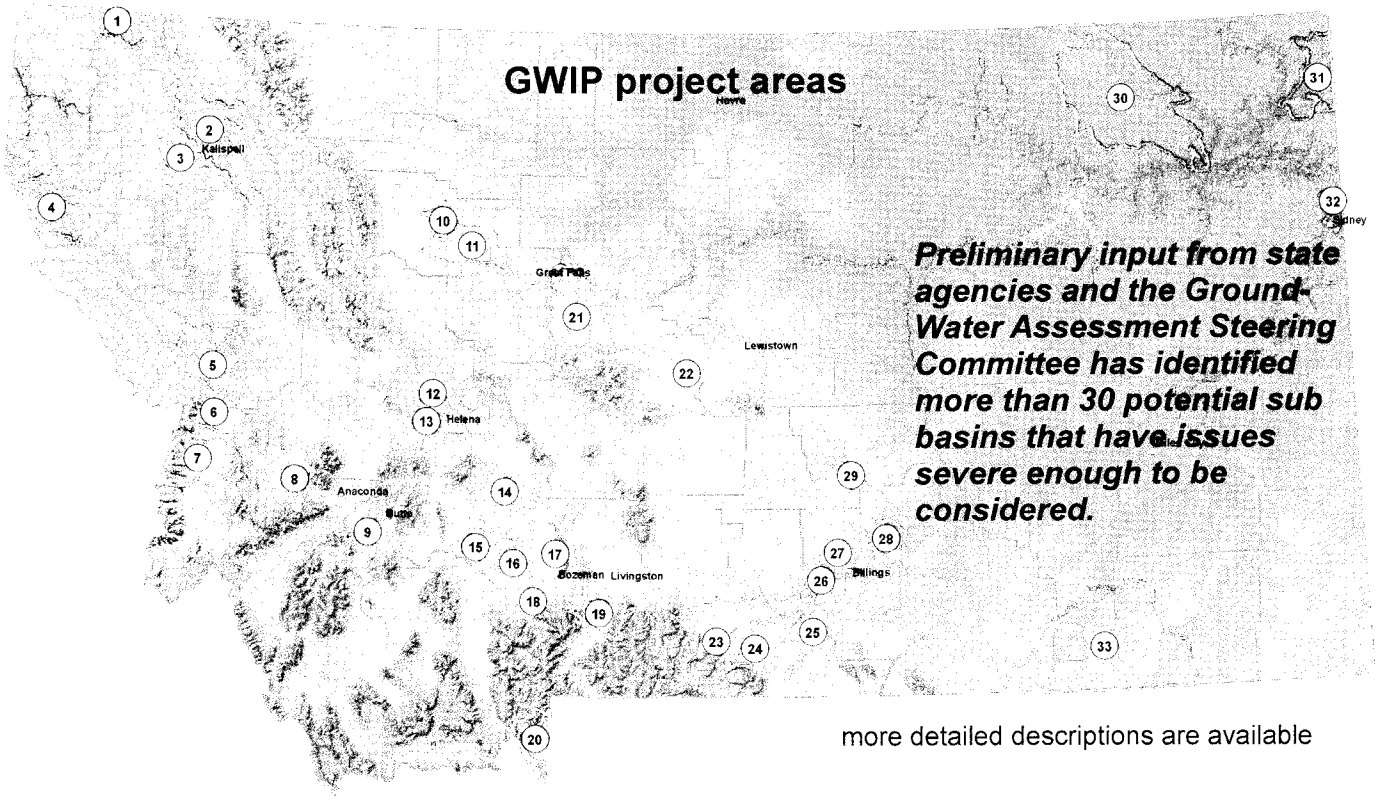
SENATE NATURAL RESOURCES
EXHIBIT NO. 2
DATE March 30, 09
BILL NO. HB 52

HB52 Ground-Water Investigations Program

The 2007/2008 Water Policy Interim Committee (WPIC) recognized that competition for water resources and the lack of detailed information on ground-water/surface water interaction has challenged informed water-resource management and development in Montana. The WPIC found that "continued and expanded study of ground-water resources is vital to shaping statewide policy as well as providing the data necessary for local decisions regarding water." HB52 was drafted by the WPIC in response to this finding.

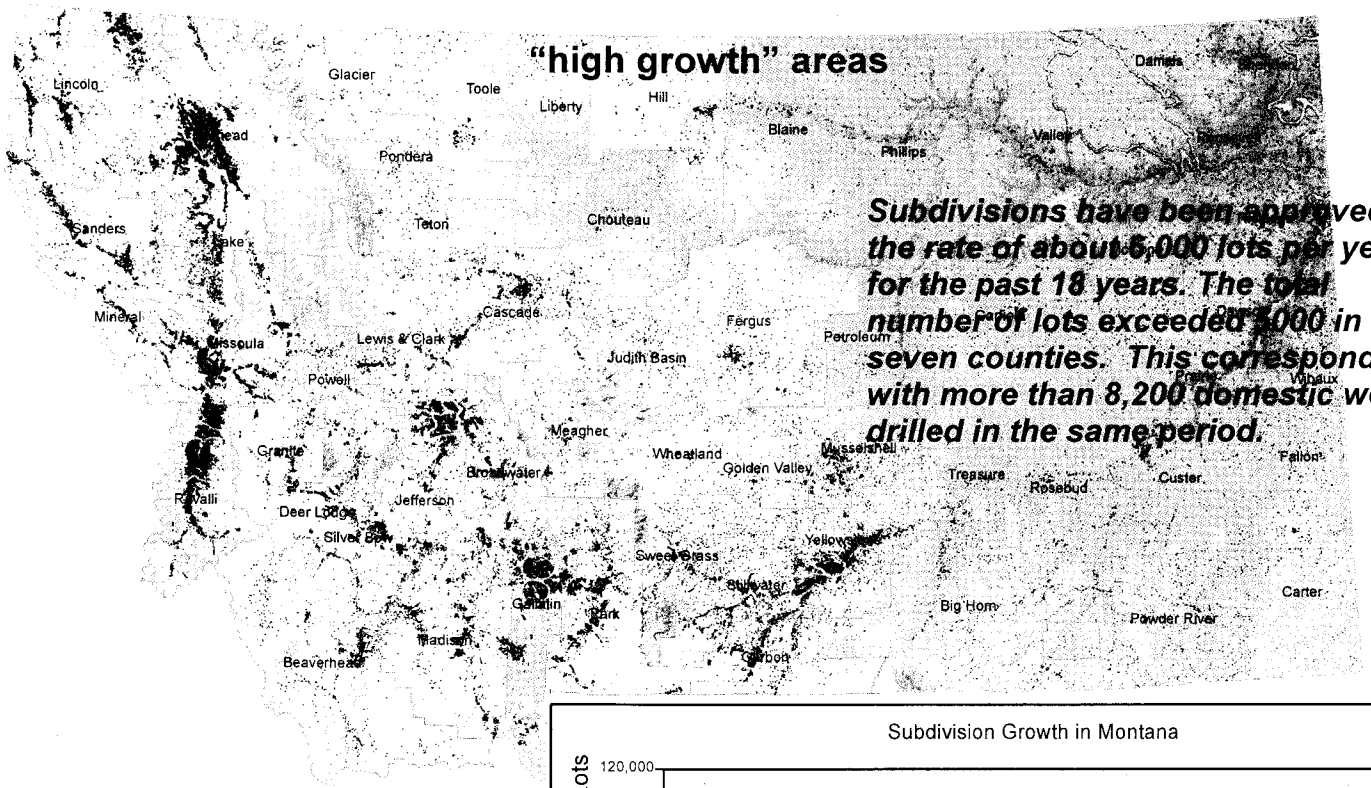
The Ground-Water Investigations Program (GWIP) established by HB52 would add to Montana's capability to deal with important water-resource issues including:

- stream depletion from ground-water development by subdivisions or irrigation projects,
- cumulative effects of existing and proposed water development on stream flow,
- impacts to ground water and surface water from changes in irrigation practices or land use,
- implementation of aquifer storage and recovery (ASR) in Montana, and
- evaluating the success of mitigation/offset plans in closed basins.



more detailed descriptions are available

1 Eureka
2 Flathead Valley
3 Smith Valley
4 Noxon
5 Missoula Valley
6 Florence
7 Hamilton
8 Georgetown Lake
Phillipsburg
9 Summit Valley
10 Priest Butte Lake
11 Greenfield Bench
12 North Hills
13 Scratchgravel Hills
14 Townsend, Toston
15 Three Forks
16 Manhattan
17 Belgrade
18 Four Corners
19 Pine Creek
20 W.Yellowstone
21 Belt, Monarch
22 Little Belt Mtns
23 Stillwater Valley
24 Rock Creek
25 Prior Mtns
26 Park City
27 West Billings
28 East Billings
29 Roundup
30 Flaxville gravels
31 Clear Lake
32 Sidney
33 Coalbed methane



HB52 elements:

- Directs the Montana Bureau of Mines and Geology to conduct 1-3 year focused investigations of ground water and surface water in high growth, or over-appropriated areas,
- Adds a member of the development community to the Ground-Water Assessment Steering Committee authorized in 2-15-1523 MCA,
- Directs the Ground-Water Assessment Steering Committee to prioritize sub basin investigations based on anticipated growth in housing, agriculture, industry and commercial activity

Ground-Water Investigation Program Products:

- Each sub basin investigation products will include:
  - A detailed report that describes the hydrogeologic system,
  - Models that simulate hydrogeologic features and processes, and
  - A comprehensive set of hydrogeologic data available through the MBMG Ground-Water Information Center (GWIC)

Each project will be a focused investigation of ground water and surface water in a sub-basin of sufficient size to construct models and a detailed report of the investigation. The models, reports, and supporting data will be technical in nature and used directly by scientists and engineers representing agencies, applicants, senior water-right holders, and other stakeholders.

Montana Bureau of Mines and Geology
DISCUSSION DRAFT
Potential Ground Water Investigation Program (GWIP) Projects
The list of sites is neither prioritized nor inclusive and is presented based on location from west to east to facilitate locating the site on the accompanying maps. The descriptions are intended to summarize potential projects and are compiled from information from the MBMG, DNRC, DEQ, and MDA.

1 Eureka	8 Georgetown Lake, Phillipsburg	15 Three Forks	22 Little Belt Mtns	29 Roundup
2 Flathead Valley	9 Summit Valley	16 Manhattan	23 Stillwater Valley	30 Flaxville gravels
3 Smith Valley	10 Priest Butte Lake	17 Belgrade	24 Rock Creek	31 Clear Lake
4 Noxon	11 Greenfield Bench	18 Four Corners	25 Prior Mtns	32 Sidney
5 Missoula Valley	12 North Hills	19 Pine Creek	26 Park City	33 Coalbed methane
6 Florence	13 Scratchgravel Hills	20 W.Yellowstone	27 West Billings	
7 Hamilton	14 Townsend, Toston	21 Belt, Monarch	28 East Billings	

1)
Name: Eureka
County: Lincoln
Approximate Area (square miles): 60
Drainage Name(s): Tobacco River
Problem Statement: As with many other areas of the state, the land use in the area near Eureka is shifting from agricultural to individual houses and subdivisions. DEQ received 1670 applications for 5556 lots from 1991 through 2008. Water availability may change as a result of changing water-use from irrigation (wells and ditches) to individual wells. Additionally, the cumulative effects on ground-water quality from individual septic systems in the area of Eureka are of concern.
Project Elements: The shift from crop irrigation wells and ditches to individual domestic wells with increasing housing density will be evaluated through ground-water and surface-water modeling. Water-level/discharge and water-quality data from wells and streams will be used to construct a detailed potentiometric maps and a water balance for the area. Deeper wells may be needed to define the extent of suspected confined aquifers. A detailed ground-water flow model would include the pumping/injection systems and evaluate the impact of growth on water availability and quality.

2)
Name: Flathead Valley: Deep Aquifer
County: Flathead
Approximate Area (square miles): 150
Drainage Name(s): Flathead, Whitefish, Stillwater
Problem Statement: Population in the basin has increased by more than 25 percent in the last decade and is currently about 70,000, all of whom, with the exception of Whitefish, rely on ground water for municipal, domestic, industrial, and irrigation supply. Continued growth and declining water levels in the main aquifer (deep confined aquifer) have raised concern about the long-term sustainability of the water supply.
Project Elements: Installation of nested wells will be used to characterize the hydrologic relationship between the shallow aquifers and the deep confined aquifer. Aquifer tests and water chemistry sampling/analyses in shallow and deep aquifers will define aquifer properties. Aquifer vulnerability will be evaluated through water chemistry and ground-water age dating. The new project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model.

3)
Name: Smith Valley
County: Flathead
Approximate Area (square miles): 30
Drainage Name(s): Ashley Creek
Problem Statement: Low well yields, increased development in the Smith Valley, and concern about de-watering Ashley Creek resulted in a petition for a controlled ground water area in 2005. Ground water is obtained from fractured bedrock and alluvial basin-fill. The sources of ground-water recharge, the relationship between the fractured bedrock and alluvial aquifers, and the stream-aquifer interaction are not well defined.
Project Elements: Installation and testing of wells in transects across the valley, in the fractured bedrock and alluvium, would be use to characterize the hydrologic relationship between the aquifers and Ashley Creek. A ground-water flow model would be used to define each aquifer as well as provide information as to the effects and limits of future development - particularly with respect to the fractured bedrock aquifer.

4)
Name: Noxon, Clark Fork River
County: Sanders
Approximate Area (square miles): 72
Drainage Name(s): Clark Fork River near Noxon
Problem Statement: Home sales and home sale prices have increased steadily over the past few years. Similarly, subdivision applications have increased from about 28 in 1990 to a recent maximum of 73 in 2006. There were 882 applications for subdivisions for a total of 3014 lots from 1991 to 2007 in Sanders County.

Project Elements: Most wells in the area are shallow; as development continues, deeper wells may become necessary. Drilling and coring at several sites would define the lithology and the bedrock/alluvium contact at depth and at the valley margins. Aquifer tests and water-chemistry sampling/analyses at shallow and intermediate depths at these sites would define aquifer properties and would be used to evaluate aquifer vulnerability. New ground-water / surface-water elevation data would be used to construct a ground-water flow model.

5)
Name: Missoula valley
County: Missoula
Approximate Area (square miles): 40
Drainage Name(s): Clark Fork River
Problem Statement: The city of Missoula is unique in Montana with its large development of ground water for the municipal water supply. However, removal of the Milltown dam, expansion of sand/gravel pits, and a rapidly expanding population are changing ground-water flow quality and quantity in the Missoula Valley. The valley-fill aquifer is comprised of coarse gravel and cobbles which makes for a very productive aquifer, but its shallow water table also provides rapid movement of contaminants. The deeper portions of the aquifer remain unexplored.
Project Elements: Development of the deeper aquifer necessitates drilling and testing of deep wells. Lithology and aquifer parameters from the test wells will be compiled with recent and new water level data to develop a ground-water flow model of the Missoula basin above its confluence with the Bitterroot River. Water quality, including pharmaceuticals and personal care products, will be assessed with regard to their potential for migration to deeper portions of the valley fill aquifer.

6)
Name: Florence Area
County: Ravalli
Approximate Area (square miles): 30
Drainage Name(s): Bitterroot, One Horse Creek, Eightmile Creek
Problem Statement: High density well and septic development in and around Florence and the Eightmile Creek Drainage have raised concerns about ground-water availability and ground-water contamination.
Project Elements: Lithologic data from drilling and coring at several sites throughout the area would be used to characterize the hydrogeologic framework. Aquifer tests and water-chemistry sampling/analyses at various depths would be used to define aquifer properties and to evaluate aquifer vulnerability. The ground-water flow model would focus on the potential depletion effects on small streams, as well as the changing ground-water flow paths, induced by new development.

7)
Name: Hamilton Area
County: Ravalli
Approximate Area (square miles): 30
Drainage Name(s): Bitterroot, One Horse Creek, Eightmile Creek
Problem Statement: Conversion of irrigated land to residential development has raised concerns about ground-water availability and ground-water contamination.
Project Elements: Drilling and coring at several sites throughout the area would define the hydrogeologic framework. Detailed canal seepage measurements would be used to characterize irrigation (incidental) recharge. Aquifer tests and water-chemistry sampling/analyses at multiple depths in the flood plain and on the upland benches will define aquifer properties to evaluate aquifer vulnerability. New project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model.

8)
Name: Georgetown Lake - Phillipsburg
County: Granite and Deer Lodge
Approximate Area (square miles): 35
Drainage Name(s): Flint Creek
Problem Statement: Rapid subdivision of private land around the lake has raised some concerns with nitrate loading on the lake. In addition, pressure for development in the Phillipsburg area increases the need to evaluate the transition from flood and center-pivot irrigation to local subdivisions. Senior water-right holders in the basin have some of the oldest water rights in the state. The shallow ground-water system has been evaluated in past investigations of irrigation return flow. The deeper aquifer(s), however, are likely to be targeted for development as the demand for water outside the influence of septic systems grows.
Project Elements: Compilation of existing surface-water and ground-water data would be used construct a conceptual model of the shallow system and serve to guide evaluation of the deeper aquifers of the Flint Creek valley. A ground-water flow model would be used to evaluate the basin-specific transition from flood/pivot irrigation to domestic use.

9)
Name: Summit Valley (Butte)
County: Silver Bow
Approximate Area (square miles): 40
Drainage Name(s): Silver Bow Creek, Blacktail Creek
Problem Statement: Ground-water below high density well and septic residential developments has been contaminated by nitrate. The elevated ground-water nitrate has also impacted Silver Bow and Blacktail Creeks. Concern about ground-water and surface water contamination from septics has restricted development in the Summit

Valley. The deep valley aquifer south of Butte may provide an opportunity for ground-water development to supply new subdivisions. Near-surface alluvial material is derived from the granitic bedrock and is quite transmissive; however, it is susceptible to contamination from septic systems. Elevated nitrate concentrations have prompted Butte-Silver Bow and DEQ to increase lot sizes in new subdivisions. Evaluation of deeper ground-water with respect to quality and quantity has not been done. Development on the valley margins relies on the fractured-bedrock aquifer that has proven to be quite variable with respect to production and vulnerable to contamination by septic systems. Although a few wells penetrate the deeper aquifer, its yield and water quality are largely un-documented.
Project Elements: Water-quality data related to nitrates and pharmaceuticals would be collected throughout the basin along with chemistry/physical properties of the local soils to estimate the fate and transport of septic effluent. Test wells would be installed in the intermediate and deep aquifer(s) of the valley fill material to estimate yield and aquifer vulnerability. A ground-water flow model would be used to evaluate ground-water development and the potential for mixing waters from shallow and deep aquifers.

10)
Name: Priest Butte Lake - Teton River
County: Teton
Approximate Area (square miles): 70
Drainage Name(s): Teton River
Problem Statement: The Teton River Water Quality Restoration Plans/TMDL called for a GW assessment of the Priest Butte Lake contributing area to assist in refinement of the salinity load allocations. *Excerpt from the Executive Summary of TetonMasterDoc8_18_03*: "Priest Butte Lakes has been briefly studied in the past, but the characteristics of the shallow groundwater that drain into the lake have not. An extensive groundwater study was completed around Freezeout Lake, Benton Lake, and the surrounding areas".
Project Elements: "For a better understanding of the load contributed to Priest Butte Lakes from the geology and groundwater, a groundwater-monitoring plan needs to be implemented. As for the remainder of the watershed, groundwater studies should take place in irrigated areas between Choteau and Bynum and along the Teton River to determine losing/gaining reaches of a stream. Identification of land practices that contribute to increased salts and salinity should be used to supplement or support groundwater data".

11)
Name: Greenfields Bench area
County: Teton
Approximate Area (square miles): 100
Drainage Name(s): Sun River / Muddy Creek
Problem Statement: Ground water in the Greenfields Bench area depends largely on

recharge from irrigation canals diverted from the Sun River via Gibson Dam and Pishkun Reservoir. Leakage from these canals into the 3 to 50 foot thick terrace gravel deposits of the bench provides recharge to domestic wells. Recent applications for subdivisions in this area indicate a growing interest to re-develop irrigated acreage for domestic use. A relatively thin aquifer will be particularly susceptible to changes in land use - with respect to both quantity and quality.
Project Elements: Previous investigations by MBMG, MDA, and others have described the hydrogeology of the area, as well as estimated water balances, for the bench area. Monitoring of water quality continues at present. The focus of this investigation will be to construct a ground-water flow model based on data compiled from previous work as well as new data. The model would be used to evaluate the potential changes in ground-water flow (levels) and quality under various land-use changes.

12)
Name: North Hills (Helena)
County: Lewis and Clark
Approximate Area (square miles): 60
Drainage Name(s): Silver Creek
Problem Statement: Expansion/addition of subdivisions and declining water levels prompted a temporary controlled ground water area; a smaller controlled ground water area was established in 2007. Questions as to aquifer type (bedrock vs alluvium) and potential production remain; aquifer vulnerability with respect to near-surface sources is also unresolved.
Project Elements: Drilling and coring at several sites throughout the area would establish lithology. Aquifer tests and water chemistry sampling/analyses at shallow and intermediate depths at these sites would be used to define aquifer properties and to evaluate aquifer vulnerability. New project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model.

13)
Name: Scratch Gravel Hills (Helena)
County: Lewis and Clark
Approximate Area (square miles): 70
Drainage Name(s): Tenmile Creek, Silver Creek
Problem Statement: Similar to the North Hills area, subdivisions and declining water levels have been observed, but lack of data prevents any cause/effect evaluation. The geology of the Scratch Gravel Hills area is much different than that of other areas in the Helena Valley. In this area, alluvial fans have been deposited on faulted granitic bedrock.
Project Elements: Drilling and coring at several sites throughout the area would establish lithology; particularly with respect to depth to bedrock. Aquifer tests and water chemistry sampling/analyses in the alluvial fans and the underlying bedrock at these

sites would be used to define aquifer properties and to evaluate aquifer vulnerability. New project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model.

14)
Name: Townsend - Toston area
County: Lewis and Clark, Broadwater
Approximate Area (square miles): 110
Drainage Name(s): Missouri River above Canyon Ferry Lake
Problem Statement: The Townsend - Toston area is along the Missouri River just above Canyon Ferry Lake. Although some subdivisions have been developed in the area, the main concern is the conversion from flood to center pivot irrigation. Similar to other areas in the state, the Toston irrigation canal and other such canals represent considerable recharge to the near-stream aquifers. There are several applications for irrigation well permits; which involve conversion from flood irrigation fed by the Toston and other canals and ditches.
Project Elements: This area would benefit from a ground-water modeling effort to evaluate the many potential changes in land use; particularly the change from flood to pivot irrigations. Test wells would be installed throughout the area to evaluate aquifer properties and extent. The model would be constructed based on existing irrigation canals and wells with an emphasis on stream depletion/accretion.

15)
Name: North of Three Forks
County: Broadwater
Approximate Area (square miles): 50
Drainage Name(s): upper Missouri
Problem Statement: Dryland, flood, and center pivot irrigation is being replaced by development of subdivisions throughout the area. Agriculture relied on deeper (200+ feet) wells for much of its water in the last few years. Domestic/exempt wells will likely become a popular means of water supply for the thousands of new lots along the Hwy 287 / I-90 corridor. Most of the ground-water development in this area will rely on semi-consolidated Tertiary-age sediments on the flanks of the upper Missouri River valley.
Project Elements: Reported well yields for this area range from less than 1 gallon per minute to over 1,000 gallons per minute; this range indicates the large variability in aquifer properties over a small area. Development of ground water and its effect on stream flow will be similarly variable. Test wells will be installed at various locations based on existing wells; aquifer tests will be used to document aquifer properties for the area. A ground water flow model will be constructed to evaluate change from a few irrigation wells to many domestic wells; emphasis will be on future development of domestic ground-water and evaluation of a few public water supply versus many individual wells.

16)
Name: Gallatin Valley Manhattan
County: Gallatin
Approximate Area (square miles): 60
Drainage Name(s): Gallatin River at Logan
Problem Statement: The Manhattan - Logan area is the spill point for the Gallatin River exiting the valley. Subdivisions have been developed in several areas west and north of Manhattan as well as the Church Hill area south of Manhattan. In addition to subdivisions, the deeper Tertiary-age aquifer has proven to be very productive for agricultural use. There are several applications for irrigation well permits; flood irrigation from canals fed by the West Gallatin River and its tributaries is being converted to center pivot irrigation fed by ground water in several areas.
Project Elements: This area warrants an intense ground-water modeling effort to evaluate the many potential changes in land use. Test wells would be installed throughout the area to evaluate aquifer properties and extent. The model would be constructed based on existing irrigation canals and wells with an emphasis on stream depletion/accretion.

17)
Name: Belgrade - Lower West Gallatin River
County: Gallatin
Approximate Area (square miles): 5
Drainage Name(s):
Problem Statement: Recent subdivisions, utilizing septic systems and community wastewater treatment, replace agricultural land-use, particularly dairy operations as well as irrigated and non-irrigated pasture. The Gallatin County Local Water Quality District collected water quality data: preliminary results suggest elevated nitrate concentrations result more from recent development than past agricultural. Their water-level data, also indicate a disparity between ground-water flow directions mapped in the 1960's versus those mapped in the 1990's. All of the wells in the area are completed at shallow depths - usually less than 100 feet - in an area where the Gallatin River is a losing stream. This area is particularly important with respect to ground-water / surface-water interaction.
Project Elements: Monitoring and test wells would be installed at key locations throughout the area to investigate ground-water flow gradients (both vertical and horizontal) and the evolution of water chemistry. A detailed elevation surface of new and existing wells to augment work done by the water quality district will be conducted. The objective of this project would be to construct a ground-water flow model of the lower West Gallatin River at and above its confluence with the East Gallatin River and Hyalite Creek.

18)
Name: Four Corners - Bozeman
County: Gallatin
Approximate Area (square miles): 5
Drainage Name(s): West Gallatin River
Problem Statement: Subdivision of agricultural land has partially evolved from individual wells and septic systems to commercial public water supply coupled with public wastewater treatment utilizing both surface and ground water. Planned or proposed expansion of the coupled system along with planned aquifer storage recovery offers alternatives to conventional water supply and treatment options. The impact of these systems has been the subject of inquery, particularly by non-participants and senior water right holders. As with other small sub basins in the Gallatin Valley, the density of development with respect to ground water and surface water warrants a detailed ground-water flow model.
Project Elements: Water-level and water-quality data collected and made available by private operators as well as researchers will be compiled and used to construct a detailed potentiometric maps and a water balance for the area. Deeper wells may be needed to define the extent of suspected confined aquifers. A detailed ground-water flow model would include the pumping/injection systems and evaluate potential managed ground-water storage on the valley margins.

18a)
Name: Sypes Canyon (Bozeman)
County: Gallatin
Approximate Area (square miles): 27
Drainage Name(s): Sypes Creek, East Gallatin River
Problem Statement: Expansion/addition of subdivisions and declining water levels prompted a temporary controlled ground water area in 2002; following a ground water study and construction of a numeric model, permanent designation was denied in 2008. Although a model prepared by DNRC gives a good representation of the overall properties of the alluvial fan aquifer system and the potential effects of increased pumping, data are not sufficient to support a model that can describe, in detail, the variability of aquifer characteristics over short distances. In addition, questions remain as to the specific mechanism and timing of recharge to the aquifer, specifically the role of the Madison Limestone found in the adjacent Bridger Mountain Range.
Project Elements: Installation of deep/shallow monitoring wells at key locations would provide detailed lithology and vertical gradient definition. Aquifer tests and water chemistry sampling/analyses at various depths would more accurately define aquifer properties and variability. Surface-water flow measurements (seepage runs) at select locations would help constrain the surface water/ground water relationships and define recharge pathways. Subsequent refinement of the existing numeric model could potentially be applied to other alluvial fan aquifers in Montana.

19)
Name: Pine Creek
County: Park
Approximate Area (square miles): 40
Drainage Name(s): Pine Creek
Problem Statement: Paradise Valley is historically a very productive agricultural landscape. The natural beauty of the Yellowstone River and the Absaroka and Gallatin Mountain ranges has made this valley a popular location for non-agricultural development. The small stream valleys on either side of Paradise Valley have been the focus of much of this development. Wells in these valleys are completed in bedrock aquifers. Bedrock aquifers may form the majority of the stream flows during low-flow periods. The interaction of these small drainages and the bedrock aquifers with the large alluvial aquifer of the Yellowstone River valley is not well understood. Increasing use of bedrock aquifers may impact baseflow on small streams thereby impacting ground-water users in the lower part of Paradise Valley.
Project Elements: A ten-mile stretch of the Yellowstone River alluvial valley, centered upon the small town of Pine Creek, and extending up into the Pine Creek Valley on the east side of Paradise Valley has been identified for modeling. Using existing data and data from monitoring wells installed as part of this project, a model will be developed which will identify: 1) the interaction of bedrock aquifers and Pine Creek, 2) the interaction of Pine Creek and the alluvial Yellowstone River valley, and 3) predict the impact future development may have upon down-gradient users and minimum flows in Pine Creek.

20)
Name: West Yellowstone, north side of Hebgen Lake
County: Madison
Approximate Area (square miles): 25
Drainage Name(s): Madison River, Grayling Creek
Problem Statement: West Yellowstone has undergone several growth cycles which prompted changes from individual to public water supply in the early 1990's. Development of subdivisions north of town, beyond the public water system, renews concerns about nitrate loading and ground-water development on Grayling Creek and the Madison River. The latter exhibits elevated concentrations of arsenic as a result of geothermal discharge from Yellowstone Park. The lower Madison River drainage has experienced problems with arsenic in ground water as a result of flooding, both natural and irrigation. Development of ground water in the Madison River flood plain could cause similar problems for new subdivisions as well as the existing PWS. The MBMG conducted a well inventory and collected some baseline samples just prior to the shift from individual wells to the PWS in the early 1990's. Other than data collected for the Yellowstone Controlled Ground Water Area monitoring program, few samples have been collected to evaluate the effects of expanded development on surface- and ground-water quality and quantity.
Project Elements: In addition to an updated well inventory, water chemistry samples would be collected with an emphasis on wells not sampled in the original work. A

ground-water flow model would address the impact of development on the smaller tributaries as well as the Madison River. The potential for arsenic contamination by pumping near the Madison would also be addressed by the model.

21)
Name: Great Falls southeast, Monarch/Belt
County: Cascade
Approximate Area (square miles): 120
Drainage Name(s): Belt Creek
Problem Statement: Subdivisions are using the Madison limestone aquifer. In the area of Monarch and Belt, most wells are in the Kootenai formation; however, as development increases and water in this shallow aquifer reaches its limit, the deep Madison Limestone will be the likely target. In this and several areas, the Madison Limestone presents a potential target for aquifer storage recovery (ASR).
Project Elements: Several wells have been completed in the Madison aquifer, but test data are limited. Existing wells with new observation wells would be tested to provide basic information for the preliminary ground-water flow model. The model results would guide additional field studies that may include installation of production/test/observation wells and geochemical studies. The modeling would evaluate the current and potential impact of development on water levels in the Madison aquifer. Additionally, modeling would be used to explore the merits of aquifer storage recovery.

22)
Name: Madison aquifer between Little Belt and Big Snowy mountains
County: Lower Judith Basin and Fergus
Approximate Area (square miles): >100
Drainage Name(s): multiple
Problem Statement: The Madison aquifer is one of the most important and wide spread aquifer systems in Montana. Recharge occurs at limited areas of outcrop around uplifted areas such as the north side of the Little Belt and Big Snowy mountains. With increasing distance from recharge, the depth to the Madison typically increases and water quality decreases. Water usability is assumed to be limited to areas near recharge. Little is known about the aquifer characteristics between the Little Belt and Big Snowy uplift. This giant aquifer system is assuredly being underutilized in some areas but increasing demand will threaten existing uses in others.
Project Elements: A digital model will be generated for the project area to help evaluate aquifer recharge, storage, production capacity, and sensitivity to impacts. Dedicated monitoring wells will be installed at several sites. Aquifer tests, water chemistry, and isotope analyses will be used to evaluate the aquifer system. The study may also include a comprehensive survey of spring discharges using geochemistry to identify the Madison as a source. A general, regional model would be constructed to help understand the timing of impacts from pumping to address concerns related to the continuing interest of using the Madison for municipal as well as industrial (coal plants) uses. Existing data will be evaluated to determine reliability, and in combination with new data collected, will be used to calibrate the model. Additional areas of Madison

recharge and utilizations will be identified for future modeling and evaluation projects.

23)
Name: Stillwater Valley bedrock aquifers
County: Stillwater
Approximate Area (square miles): 221mi
Drainage Name(s): Rosebud Creek, Stillwater River
Problem Statement: Land in this area that has traditionally been agricultural range or hay land is increasingly being subdivided. The density of wells is increasing and will continue to increase as each lot requires a water supply. This conversion of land use pits and newer water rights against each other, typically with little data to support either side. Questions about the source of recharge to the bedrock aquifers prompted the formation of the Horse Creek Temporary Controlled Ground Water Area. The interaction between the ground-water and surface-water systems is also a sensitive issue that needs to be resolved.
Project Elements: Detailed aquifer parameters will be collected by drilling and completing dedicated monitoring wells in specific geologic units. Aquifer pumping tests, water chemistry and isotope analyses will be used to identify recharge, flow direction and evaluate aquifer sensitivity and water quality. The new data collected along with existing data will be used to create a bedrock ground-water flow model with an interface with the rivers. Currently, an alluvial ground-water/surface-water model is being constructed on the middle reach of the Stillwater River. These two models will lend understanding to the sensitivity of the bedrock and alluvial aquifers in the region.

24)
Name: Rock Creek (Red Lodge to Joliet)
County: Carbon
Approximate Area (square miles): 100
Drainage Name(s): Rock Creek/Clark's Fork of the Yellowstone
Problem Statement: Shallow aquifers underlie alluvial terraces along Rock Creek from the Mountains to the confluence with the Clark's Fork of the Yellowstone River. Recharge appears to be dominated by artificial recharge associated with flood irrigation. The land along Rock Creek is being rapidly subdivided and developed changing the predominant land use from flood irrigated agriculture to suburban and vacation housing. There is a significant need to understand and manage these aquifer resources to protect existing supplies and surface water resources while developing additional water for domestic supplies, communities, agriculture, and industry. Since this aquifer is artificially recharged, changing land uses and methods of water distribution may significantly impact the aquifer and existing water resources. The primary goal of this project is to determine potential changes to water resources caused by the change in land use.
Project Elements: Drilling and well construction are needed to better define the geometry of the aquifer system. Aquifer tests, response tests, water-use monitoring, water-level monitoring and water-chemistry sampling/analyses are needed to define the hydrogeology and better define aquifer properties and would be used to evaluate

aquifer vulnerability. New project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model.

25)
Name: Pryor Mountains/Clark's Fork
County: Carbon
Approximate Area (square miles): 50
Drainage Name(s): Rock Creek and Clark's Fork of the Yellowstone
Problem Statement: Population growth and interest in deep aquifers has prompted increased drilling in the Silesia-Rockvale-Edgar area. Madison aquifer recharge originates along the northwest flank of the Pryor Mountains. Known discharge from the Madison is to springs such as the Blue Water Fish Hatchery and wells but, this represents a small fraction of the available recharge and little is known of the discharge from the Madison in this area. Overlying aquifers are recharged further north toward Five Mile and Cottonwood creeks. However, overlying aquifers such as the Frontier Sandstone near the top of the Belle Fourche are surprisingly productive in some areas. The Frontier subcrops in the Clark's Fork alluvium while the Kootenai and Madison dip under the valley fill. Flowing wells in the Rockvale area indicate that upward flow through fractures from the Kootenai or Madison may be a source of recharge to the shallower aquifers.
Project Elements:
Three deep monitoring wells will be drilled. Extensive water quality, isotope analyses, and geochemical modeling (e.g. MINTEQ) will be used to identify the source of water in these aquifers and interconnections between the bedrock aquifers. Samples will be collected from wells and springs. Aquifer tests, water level data, chemical and isotope data will be used to generate a conceptual model. A digital model will be built upon the conceptual model and calibrated against the collected data. Though south of this project area, results from several past studies of the Blue Water Creek area will be included in development of the conceptual model.

26)
Name: Park City
County: Stillwater
Approximate Area (square miles): 40
Drainage Name(s): Yellowstone River Valley
Problem Statement: Population in Stillwater County has grown by 32% since 1990 (2007 census data). Expanding development west of Laurel to Park City is mainly taking the form of 1 to 5 acre "ranchettes" which replace irrigated farmland. Flood irrigation of the valley has been shown to create shallow aquifers that are then used as a source of domestic water. Reducing or removing the source of recharge by converting flood irrigated land to subdivisions will lower the water table, potentially impacting existing water users. Some areas may be extremely sensitive to loss of irrigation recharge, while others may not. Identification of the sensite areas of the shallow aquifers will allow scientifically based decision making to guide county planning

along the Yellowstone River.
Project Elements: Aquifer characterization that has been well documented from Billings to Laurel will be extended to Park City to account for the large number of new houses using exempt wells in this area. Monitoring of private wells, in addition to dedicated monitoring wells installed and instrumented with data loggers as part of this project, will be used to characterize seasonal ground-water fluctuations and trends. These trends, in conjunction with irrigation ditches, springs and stream flows, will be used to calibrate a model which can be used to predict future trends under increasing aquifer use and decreasing irrigation.

27)
Name: West Billings
County: Yellowstone
Approximate Area (square miles): 60
Drainage Name(s): Yellowstone River
Problem Statement: Shallow aquifers underlie alluvial terraces in the Yellowstone Valley near Billings Recharge appears to be dominated by artificial recharge associated with flood irrigation. The West Billings area is being rapidly subdivided and developed changing the predominant land use from flood irrigated agriculture to suburban housing. There is a significant need to understand and manage these aquifer resources to protect existing supplies and surface water resources while developing additional water for communities, agriculture, and industry. Since this aquifer is artificially recharged changing land uses and methods of water distribution may significantly impact the aquifer and existing water resources. One goal would be to define important recharge areas and mitigate land-use and operational changes in these areas to maximize recharge. A particular interest for the city of Billings is to develop artificial recharge basins using storm-water runoff to maintain these aquifers thereby reducing demand on the municipal water supply and more importantly reduce treatment requirements of storm water which appear to be on the regulatory horizon because of TMDL.
Project Elements: Drilling and well construction are needed to better define the geometry of the aquifer system. Aquifer tests, response tests, water-use monitoring, water-level monitoring and water chemistry sampling/analyses are needed to define the hydrogeology and better define aquifer properties and would be used to evaluate aquifer vulnerability. New project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model. A pilot project may be possible in partnership with the city of Billings to assess the potential of developing storm-water recharge basins as a method of ground-water recharge.

28)
Name: East Billings development (Huntley to Worden)
County: Yellowstone
Approximate Area (square miles): 36
Drainage Name(s): Yellowstone River Valley

Problem Statement: Population growth in Yellowstone County, centered around Billings, is expanding suburban development east toward Huntley. As a consequence of population growth in the Yellowstone River valley irrigated farmland is being converted into small subdivision lots of various sizes. The farm land in this area has been intensively irrigated for over 100 years. The irrigation has created a situation referred to by some as "incidental recharge" creating aquifers through artificial recharge. The shallow aquifers are now the source of water for many domestic wells in the subdivisions. Continued reduction in recharge by pavement and reduced irrigation application, will lower the water table and reduce the water available to wells.
Project Elements: The project will be designed to evaluate aquifer recharge mechanisms, storage and long-term yield, interpretations that will allow better decisions on future ground-water utilization. In east Billings, aquifer characterization has been documented by monitoring of private wells, water quality samples, and stream/ditch flows. Additional data are needed from dedicated monitoring wells, drilled to specific depths at selected locations. All available data will be used to create a conceptual model. A digital ground- water flow model will then be created and calibrated to the data. The model will then be used as a tool to help understand aquifer trends in similar incidental recharge areas.

29)
Name: Enhanced ground-water storage / aquifer storage recovery in underground mines near Roundup
County: Musselshell
Approximate Area (square miles): 20
Drainage Name(s): Musselshell River
Problem Statement: Ground-water and surface-water shortages are typical in the Roundup area. In the 1980's the Lower Musselshell Conservation District initiated a study of abandoned underground coal mines along the river valley in an effort to help alleviate shortages in the Musselshell River. It was determined that about 17,000 acre-feet of water is in storage, and that some of the mines are in hydrologic communication with the river alluvium. However, further testing was halted at that time due to the presence of trace concentrations of pentachlorophenol in the water from one monitoring well. Since that time, better treatment and analytical tools have been developed that may allow this concept to move forward. However, interaction between shallower aquifers and the mine pools will require modeling to determine possible impacts.
Project Elements: Several dedicated monitoring wells will be installed into the mine voids and to the overlying aquifers. These will be equipped with data loggers, and will be sampled for isotopes, organic and inorganic constituents. A digital model will be developed to evaluate current routes of recharge to the mine voids and the potential impacts to local water users of fluctuating water levels in the mine voids. Ultimately, the mines could be recharged during high flow periods by the Musselshell River, as they are lower than the river. Water would be withdrawn by pumping from the mines and discharging to the river, allowing a significant reservoir increase without loss to evaporation.

30)
Name: Flaxville/ Quaternary Terrace Aquifer System (Opheim/Larslan)
County: Valley/Roosevelt
Approximate Area (square miles): 100
Drainage Name(s): Porcupine Creek/West Fork Poplar River/Missouri River
Problem Statement: Significant irrigation development has occurred in this area and there is an increasing demand for additional development. Ancestral Missouri River gravels of the Flaxville Formation and younger Quaternary deposits form an aquifer ranging from 20-100 feet thick across much of this area. The aquifer system is dissected by surface drainages resulting in a number of isolated aquifer systems. The current water use is significantly less than the original development because of conversion from low efficiency high pressure pivots to more efficient low pressure pivots. A better understanding of the hydrogeologic conditions is needed to maximize use of existing water resources without depleting surface water resources.
Project Elements: Drilling and well construction are needed to better define the geometry of the aquifer system. Aquifer tests, response tests, water-use monitoring, water-level monitoring and water-chemistry sampling/analyses are needed to define the hydrogeology and better define the hydraulic connection between the aquifers and wetlands. New project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model. The ultimate goal will be a detailed aquifer management model that could be used to predict development impacts.

31)
Name: Clear Lake Aquifer System
County: Sheridan
Approximate Area (square miles): 60
Drainage Name(s): Big Muddy
Problem Statement: Significant irrigation development has occurred in this area because of cooperation between the US Fish and Wildlife Service and the Sheridan County Conservation District that resulted in a ground-water reservation. Aquifer monitoring has been the key to this cooperation and is planned to be continued indefinitely. Additional aquifer definition needs to be accomplished to provide data to allow additional development without impacting water bodies and migratory bird habitat managed by the Medicine Lake Wildlife Refuge.
Project Elements: Drilling and well construction are needed to better define the geometry of the aquifer system. Aquifer tests, response tests, water-use monitoring, water-level monitoring and water chemistry sampling/analyses are needed to define the hydrogeology and better define the hydraulic connection between the aquifers and wetlands. New project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model. The ultimate goal will be a detailed aquifer management model that could be used to predict development impacts.

32)
Name: Lower Yellowstone Buried Channel Aquifers (Sidney)
County: Richland
Approximate Area (square miles): 70
Drainage Name(s): Yellowstone River
Problem Statement: A buried-channel aquifer from 1 to 4 miles wide by 26 to 40 miles long underlies the Yellowstone Valley through Richland County. Recharge appears to be dominated by artificial recharge associated with flood irrigation. The aquifer is a significant source for stock, domestic, industrial and community supplies. There is a significant need to understand and manage this resource to protect existing supplies and surface water resources while developing additional water for communities, agriculture, and industry. Since this aquifer is artificially recharged changing land uses and methods of water distribution may significantly impact the aquifer and existing water resources. One goal would be to define important recharge areas and mitigate land-use and operational changes in these areas to maximize recharge.
Project Elements: Drilling and well construction are needed to better define the geometry of the aquifer system. Aquifer tests, response tests, water-use monitoring, water-level monitoring and water chemistry sampling/analyses are needed to define the hydrogeology and better define aquifer properties and would be used to evaluate aquifer vulnerability. New project data along with ground-water / surface-water elevation data from recent studies throughout the area would be used to construct a ground-water flow model.

33)
Name: Coalbed Methane Ground-Water Model
County: Big Horn, Rosebud, and Powder River
Approximate Area (square miles): 20 mi^2 for modeling; 100 mi^2 for isotope analyses
Drainage Name(s): Squirrel Creek and Hanging Woman Creek, Powder River
Problem Statement: Development of coalbed methane reserves in southeastern Montana and northeastern Wyoming requires the extraction of large amounts of ground water from coal aquifers. Ground-water and surface-water resources in Montana stand to be impacted by development in both states. Sources and rates of recharge for these aquifers are not understood, therefore long-term implications for the withdrawal of ground water are not known.
Project Elements: As part of ongoing work, water-level and general water-quality data have been collected in this part of Montana for several decades. Monitoring wells and methane production wells will be sampled for carbon and other isotopes which will help fingerprint the sources of recharge for water withdrawn during coalbed methane production. General chemistry, isotope data, and water-level responses will be combined to generate conceptual models for two specific areas: Squirrel Creek area encompassing late stages of methane production and near a recharge area; and Hanging Woman Creek area in the center of the Powder River Basin where aquifers are generally deeper and production is in the earlier stages. The conceptual models will be used to build digital models, which will be calibrated against monitoring data. Modeling of these data will help define areas and extent of aquifer drawdown due to future

development, and identification of recharge potential. Additional monitoring wells may be installed as data gaps are identified. Additional sites that require models will be identified in the future and results of this work will be transferred and updated to those sites.